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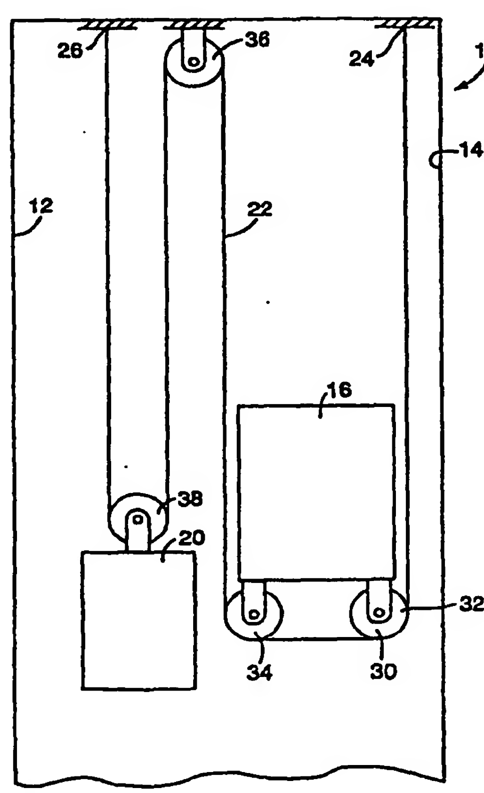
(57) Abstract

A machine-roomless elevator system (10) includes an elevator car (16) propelled by an elevator machine (32) mounted thereon and at least one flat rope (22) for suspending the elevator car (16) and providing traction therefor. Use of flat ropes combined with various roping arrangements reduces the size of the elevator machine (32) required to propel the elevator car (16). Smaller size elevator machines are more practical and result in cost savings for the elevator system (10). Additionally, placement of the elevator machine (32) on the elevator car (16) provides a safer environment for the elevator maintenance crew.



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MACHINE-ROOMLESS ELEVATOR SYSTEM WITH AN ELEVATOR MACHINE MOUNTED ON AN ELEVATOR CAR

BACKGROUND OF THE INVENTION

1. Technical Field

The present invention relates to a machine-roomless elevator system and, more particularly, to a machine-roomless elevator system with an elevator machine mounted on an elevator car and using flat ropes for traction and suspension of the elevator car.

2. Background Art

Conventional traction elevator systems include an elevator car and a counterweight, each suspended on opposite ends of a hoist rope in an elevator hoistway. The hoist ropes are driven by a drive sheave rotated by an elevator machine. In conventional elevator systems, the elevator machines are disposed in a machine room. Typically, the machine rooms are constructed above the hoistway to house the machine and to provide sufficient space for an elevator maintenance crew to service the equipment disposed therein.

The presence of the machine rooms for each elevator in a building has become increasingly problematic in the industry. First, there is considerable expense for a building owner to construct a machine room. Second, real estate scarcity induces space constraints that make it desirable to use space for other purposes. These considerations and drawbacks become magnified when a building includes multiple elevators, each requiring a machine room and therefore increasing the construction costs and encroaching on additional space in the building. Thus, there has been a movement in the elevator industry to provide systems that do not require machine rooms.

Some existing systems include an elevator machine disposed in the hoistway. One drawback of having a machine suspended in the hoistway is the difficulty of servicing the machine. The elevator mechanics must work on the machine while in the hoistway, resulting in a dangerous work environment.

Many efforts to design machine-roomless elevator systems have failed because elevator machines, required to produce sufficient torque to move the elevator car, were too large, expensive, and heavy. Therefore, there is a need for a practical machine-roomless elevator system.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an elevator system that does not require a machine room.

It is another object of the present invention to provide a machine-roomless elevator system that allows elevator mechanics easy access to the elevator machine.

It is a further object of the present invention to provide a machine-roomless elevator system that is practical.

According to the present invention, an elevator system includes an elevator car driven by an elevator machine attached thereto and a plurality of flat ropes that cooperate with the elevator machine to provide traction and suspension for the elevator car. The elevator system further includes a drive sheave, either driven by or incorporated into the elevator machine, for engaging the plurality of hoist ropes and a plurality of idler sheaves to provide traction and to suspend the elevator car in the hoistway. Use of flat ropes significantly reduces requirements for the sheave diameter and size of the elevator machine, thereby making it practical for the elevator machine to be onboard the elevator car.

One embodiment of the present invention discloses two ends of the hoist ropes that are fixedly attached to the building structure and a plurality of idler sheaves arranged within the hoistway providing a one-to-one (1:1) ratio of drive sheave speed to elevator car speed. An alternate embodiment includes a plurality of idler sheaves arranged in the hoistway to provide a three-to-one (3:1) ratio of drive sheave speed to elevator car speed. This arrangement reduces the torque requirement for the elevator machine by a factor of three (3). A further alternate embodiment discloses the ends of the hoist ropes attaching to the elevator car and the counterweight, respectively, and a

plurality of idler sheaves arranged in the hoistway for engaging the hoist ropes that provide traction and suspension for the elevator car with a two-to-one (2:1) ratio of drive sheave speed to elevator car speed, thereby reducing the torque requirement for the elevator machine by a factor of two (2). The reduction in the torque requirement for the elevator machine results in a further reduction in size of the machine, making the elevator machine even more compact and lighter.

One advantage of the present invention is that it eliminates the need for the machine room. Another advantage of the present invention is that it allows elevator mechanics to service elevator machines from the inside of the elevator car when an access panel is provided in the car. An additional advantage of the present invention is that the hoist ropes are used for both traction and suspension of the elevator car.

The foregoing and other advantages of the present invention become more apparent in light of the following detailed description of the exemplary embodiments thereof, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation of a machine-roomless elevator system with an elevator machine attached to an elevator car and traveling therewith, according to the present invention;

FIG. 2 is a schematic perspective representation of the machine-roomless elevator system of FIG. 1 with a varying roping arrangement;

FIG. 3 is a schematic perspective representation of the machine-roomless elevator system of FIG. 2 with a different idler sheave and roping arrangement, according to an alternate embodiment of the present invention;

FIG. 4 is a schematic perspective representation of the machine-roomless elevator system of FIG. 3 with a varying roping arrangement;

FIG. 5 is a schematic perspective representation of the machine-roomless elevator system with an alternate sheave and roping arrangements, according to another alternate embodiment of the present invention; and

FIG. 6 is a schematic top view of the machine-roomless elevator system of FIG. 5.

FIG. 7 is a sectional, side view of a traction sheave and a plurality of flat ropes, each having a plurality of cords.

FIG. 8 is a sectional view of one of the flat ropes.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, a machine-roomless elevator system 10 disposed in a hoistway 12 of a building structure 14 includes an elevator car 16 moving within the hoistway 12 alternatingly with a counterweight 20. The elevator car 16 and the counterweight 20 are suspended by a single hoist rope or a plurality of hoist ropes, shown schematically as a single rope 22. The hoist ropes 22 include first hoist rope ends 24 and second hoist rope ends 26. Each rope end 24, 26 is fixedly attached either directly or indirectly to the building structure 14. For example, the rope ends 24, 26 may be attached to guide rails (not shown) that are fixedly attached to the building structure 14.

A drive sheave 30 and an elevator machine 32 are mounted onto the elevator car 16. In FIGs. 1 and 2, the elevator machine 32 is shown to be disposed below the elevator car 16. A deflector sheave 34 is disposed substantially across from the drive sheave 30 and is also mounted onto the elevator car 16. A plurality of idler sheaves 36, 38 directs and guides the hoist ropes 22 within the hoistway 12.

The first ends 24 of the hoist ropes 22 are fixedly secured to the building structure 14 with the hoist ropes 22 then being engaged by the drive sheave 30, driven the by elevator machine 32. The ropes 22 subsequently pass over the deflector sheave 34. The ropes 22 are either single or double wrapped about the deflector and drive sheaves 34, 30, as can be seen in FIGs. 1 and 2, respectively. The double wrapping has an advantage of providing additional traction to the

elevator system 10 with less wear. The ropes 22 subsequently pass over the idler sheave 36 which is attached either directly or indirectly to the building structure 14. The ropes 22 then pass under the idler sheave 38 disposed at the counterweight 20 and subsequently terminate with the second rope ends 26 attaching onto the building structure 14.

In operation, the elevator car 16 is self-propelled through the hoistway 12 with the hoist ropes 22 providing both traction and suspension. As the elevator machine 32 rotates the drive sheave 30, the ropes 22 move the elevator car 16 vertically up or down in the hoistway 12 alternatingly with the counterweight 20. Thus, this embodiment of the present invention eliminates the need for a machine room for the elevator system 10. In the preferred embodiment of this configuration, flat ropes are used to provide additional traction and to allow use of smaller sheaves and elevator machines. One example of flat ropes that can be used to implement the present invention is described in a commonly owned copending U.S. Patent Application Serial Number 09/031,108, entitled "Tension Member for an Elevator", filed February 26, 1998, which is incorporated herein by reference. Use of smaller machines not only reduces the cost of the system 10, but also reduces the size and weight of the elevator machine, thereby making it possible to co-locate the elevator machine 32 with the elevator car 16. Additionally, use of hoist ropes 22 for both traction and suspension eliminates the need for two sets of ropes.

Referring to FIG. 3, an alternate embodiment of the present invention depicts a machine-roomless elevator system 110 having an elevator car 116 propelled by an onboard elevator machine 132 that is mounted thereon. The machine 132 drives a drive sheave 130 that is either attached to the machine 132 or incorporated therein. The elevator system 110 also includes a deflector sheave 134 and a plurality of idler sheaves 135-141. The idler sheaves 135, 136 are fixedly attached to elevator car 116 and the idler sheaves 139, 141 attach to the counterweight 120. The idler sheaves 137, 138, 140 are mounted either directly of indirectly onto the building structure 114. The hoist rope ends 124, 126 are also fixedly secured either directly or indirectly onto the building structure 114. First, the hoist ropes 122

pass over the idler sheaves 135, 136 and then over the idler sheave 137. Then, the ropes 122 are wrapped around the drive and deflector sheaves 130, 134. Subsequently, ropes 122 are guided by the idler sheaves 138, 139, 140, 141, respectively. The ropes 122 are either single or double wrapped about the deflector and drive sheaves, as can be seen in FIGs. 3 and 4, respectively.

In operation, the elevator machine 132 rotates the drive sheave 130 that drives the ropes 122, thereby propelling the elevator car 116 within the hoistway 112. This rope arrangement provides additional advantages over the first embodiment of the present invention. This rope arrangement provides a three-to-one (3:1) ratio of drive sheave speed to elevator car speed, thereby reducing torque requirement for the elevator machine and thus, allowing use of a much smaller machine. This further reduction in machine size is highly desirable in elevator systems and represents additional reduction in required space and weight of the machine, as well as cost savings.

Referring to FIGs. 5 and 6, in another alternate embodiment of the present invention, a machine-roomless elevator system 210 includes an elevator car 216 and a counterweight 220 suspended by hoist ropes 222. The ropes 222 include first rope ends 224 that are fixedly secured to the elevator car 216 and second rope ends 226 that are fixedly secured to the counterweight 220. The ropes 222 are driven by an elevator machine 232 through a drive sheave 230. The elevator machine 232 and the drive sheave 230 are mounted onto the elevator car 216. A deflector sheave 234 is also attached to the elevator car 216. A plurality of idler sheaves 235-238 are disposed within the hoistway 212. Idler sheaves 235, 236, 238 are fixedly secured either directly or indirectly to the building structure 214 at the top portion of the hoistway 212 and the idler sheave 237 is fixedly attached either directly or indirectly to the building structure 214 at the bottom portion of the hoistway 212. An access panel 250 is formed within the elevator car 216 to allow access to the elevator machine 232.

The ends 224 of the hoist ropes 222 are first attached to elevator car 216, then the ropes 222 pass over the idler sheaves 235, 236, respectively, and then over the deflector and drive sheaves 234, 230. Subsequently, the ropes 222 are guided over the idler sheaves 237,

238 and then terminate at the counterweight 220. This rope arrangement provides a two-to-one (2:1) ratio of drive sheave speed to elevator car speed, thereby reducing torque requirement for the elevator machine and thus allows use of a smaller machine.

One advantage of the present invention is that the elevator machine mounted on the elevator car described herein can be serviced in a relatively safe environment for the maintenance crew. The elevator machines can be accessed from the inside of the elevator car through the access panel provided therein.

A principal feature of the present invention is the flatness of the ropes used in the above described elevator system. The increase in aspect ratio results in a rope that has an engagement surface, defined by the width dimension "w", that is optimized to distribute the rope pressure. Therefore, the maximum rope pressure is minimized within the rope. In addition, by increasing the aspect ratio relative to a round rope, which has an aspect ratio equal to one, the thickness "t1"of the flat rope (see FIG. 7) may be reduced while maintaining a constant cross-sectional area of the portions of the rope supporting the tension load in the rope.

As shown in FIG. 7 and 8, the flat ropes 722 include a plurality of individual load carrying cords 726 encased within a common layer of coating 728. The coating layer 728 separates the individual cords 726 and defines an engagement surface 730 for engaging the traction sheave 724. The load carrying cords 726 may be formed from a high-strength, lightweight non-metallic material, such as aramid fibers, or may be formed from a metallic material, such as thin, high-carbon steel fibers. It is desirable to maintain the thickness "d" of the cords 726 as small as possible in order to maximize the flexibility and minimize the stress in the cords 726. In addition, for cords formed from steel fibers, the fiber diameters should be less than .25 millimeters in diameter and preferably in the range of about .10 millimeters to .20 millimeters in diameter. Steel fibers having such diameter improve the flexibility of the cords and the rope. By incorporating cords having the weight, strength, durability and, in particular, the flexibility characteristics of such materials into the flat

ropes, the traction sheave diameter "D" may be reduced while maintaining the maximum rope pressure within acceptable limits.

The engagement surface 730 is in contact with a corresponding surface 750 of the traction sheave 724. The coating layer 728 is formed from a polyurethane material, preferably a thermoplastic urethane, that is extruded onto and through the plurality of cords 726 in such a manner that each of the individual cords 726 is restrained against longitudinal movement relative to the other cords 726. Other materials may also be used for the coating layer if they are sufficient to meet the required functions of the coating layer: traction, wear, transmission of traction loads to the cords and resistance to environmental factors. It should be understood that although other materials may be used for the coating layer, if they do not meet or exceed the mechanical properties of a thermoplastic urethane, then the benefits resulting from the use of flat ropes may be reduced. With the thermoplastic urethane mechanical properties the traction sheave 724 diameter is reducible to 100 millimeters or less.

As a result of the configuration of the flat rope 722, the rope pressure may be distributed more uniformly throughout the rope 722. Because of the incorporation of a plurality of small cords 726 into the flat rope elastomer coating layer 728, the pressure on each cord 726 is significantly diminished over prior art ropes. Cord pressure is decreased at least as $n^{-1/2}$, with n being the number of parallel cords in the flat rope, for a given load and wire cross section. Therefore, the maximum rope pressure in the flat rope is significantly reduced as compared to a conventionally roped elevator having a similar load carrying capacity. Furthermore, the effective rope diameter 'd' (measured in the bending direction) is reduced for the equivalent load bearing capacity and smaller values for the sheave diameter 'D' may be attained without a reduction in the D/d ratio. In addition, minimizing the diameter D of the sheave permits the use of less costly, more compact, high speed motors as the drive machine.

A traction sheave 724 having a traction surface 750 configured to receive the flat rope 722 is also shown in FIG. 7. The engagement surface 750 is complementarily shaped to provide traction and to guide the engagement between the flat ropes 722 and the sheave

724. The traction sheave 724 includes a pair of rims 744 disposed on opposite sides of the sheave 724 and one or more dividers 745 disposed between adjacent flat ropes. The traction sheave 724 also includes liners 742 received within the spaces between the rims 744 and dividers 745. The liners 742 define the engagement surface 750 such that there are lateral gaps 754 between the sides of the flat ropes 722 and the liners 742. The pair of rims 744 and dividers, in conjunction with the liners, perform the function of guiding the flat ropes 722 to prevent gross alignment problems in the event of slack rope conditions, etc. Although shown as including liners, it should be noted that a traction sheave without liners may be used.

While the present invention has been illustrated and described with respect to a particular embodiment thereof, it should be appreciated by those of ordinary skill in the art, that various modifications to this invention may be made without departing from the spirit and scope of the present invention. For example, location of the drive and deflector sheaves is interchangeable. Also, although elevator machines 32, 132 are shown to be located below the elevator car 16, 116, these machines 32, 132 can be mounted onto sides, top or any other location on the elevator car. Similarly, location of the elevator machine 232 can vary.

We claim:

1. An elevator system disposed in a hoistway of a building structure comprising:

an elevator car traveling within said hoistway;

a flat hoist rope for providing traction and suspension to said elevator car; and

an elevator machine secured to said elevator car for driving said flat hoist rope.

2. An elevator system according to claim 1 wherein said elevator machine is disposed below said elevator car.

3. An elevator system according to claim 1 wherein said elevator machine is disposed above said elevator car.

4. An elevator system according to claim 1 wherein said elevator machine is disposed on a side of said elevator car.

5. An elevator system according to claim 1 further comprising:

a drive sheave coupled to said elevator machine and engaging said hoist rope; and

a plurality of idler sheaves disposed within said hoistway to facilitate elevator system roping arrangement for maintaining a one-to-one ratio of drive sheave speed to elevator car speed.

6. An elevator system according to claim 1 further comprising:

a drive sheave coupled to said elevator machine and engaging said hoist rope; and

a plurality of idler sheaves disposed within said hoistway to facilitate elevator system roping arrangement for maintaining a two-to-one ratio of drive sheave speed to elevator car speed.

7. An elevator system according to claim 1 further comprising:

a drive sheave coupled to said elevator machine and engaging said hoist rope; and

a plurality of idler sheaves disposed within said hoistway to facilitate elevator system roping arrangement for maintaining a three-to-one ratio of drive sheave speed to elevator car speed.

8. An elevator system according to claim 1 further comprising:

a counterweight traveling within said hoistway alternatingly with said elevator car.

9. An elevator system according to claim 1 wherein said elevator machine further comprises:

an access panel formed within said elevator car to allow elevator maintenance crew access to said elevator machine from inside of said elevator car.

10. A machine-roomless elevator system disposed in a hoistway of a building structure comprising:

an elevator car traveling within said hoistway;

a hoist rope for providing traction and suspension to said elevator car;

an elevator machine secured to said elevator car for driving said hoist rope;

a drive sheave coupled to said elevator machine and engaging said hoist rope; and

a plurality of idler sheaves disposed within said hoistway to facilitate elevator system roping arrangement for maintaining at least a two-to-one ratio of drive sheave speed to elevator car speed.

11. An elevator system disposed in a hoistway of a building structure comprising:

an elevator car traveling within said hoistway;

a counterweight traveling within said hoistway alternatingly with said elevator car;

an elevator machine secured to said elevator car;

a drive sheave coupled to said elevator machine;

a deflector sheave disposed substantially adjacent to said drive sheave;

a first idler sheave disposed within said hoistway and fixedly attached to said building structure at a top portion of said hoistway;

a second idler sheave disposed within said hoistway and fixedly attached to said building structure at said top portion of said hoistway, said second idler sheave being spaced apart from said first idler sheave;

a third idler sheave disposed within said hoistway and fixedly attached to said building structure at a bottom portion of said hoistway;

a fourth idler sheave disposed within said hoistway and fixedly attached to said building structure at said top portion of said hoistway, said fourth idler sheave being spaced apart from said first and second idler sheaves; and

at least one hoist rope having a first hoist rope end attaching onto said elevator car, a second hoist rope end attaching onto said counterweight, and a middle portion, said middle portion of said hoist rope engaging said drive sheave and said deflector sheave, said first hoist rope end engaging said first and second idler sheaves prior to engaging said deflector sheave, said second end of said hoist rope engaging said third and forth idler sheaves prior to engaging said drive sheave, said hoist rope suspending said elevator car and said counterweight and providing traction therefor.

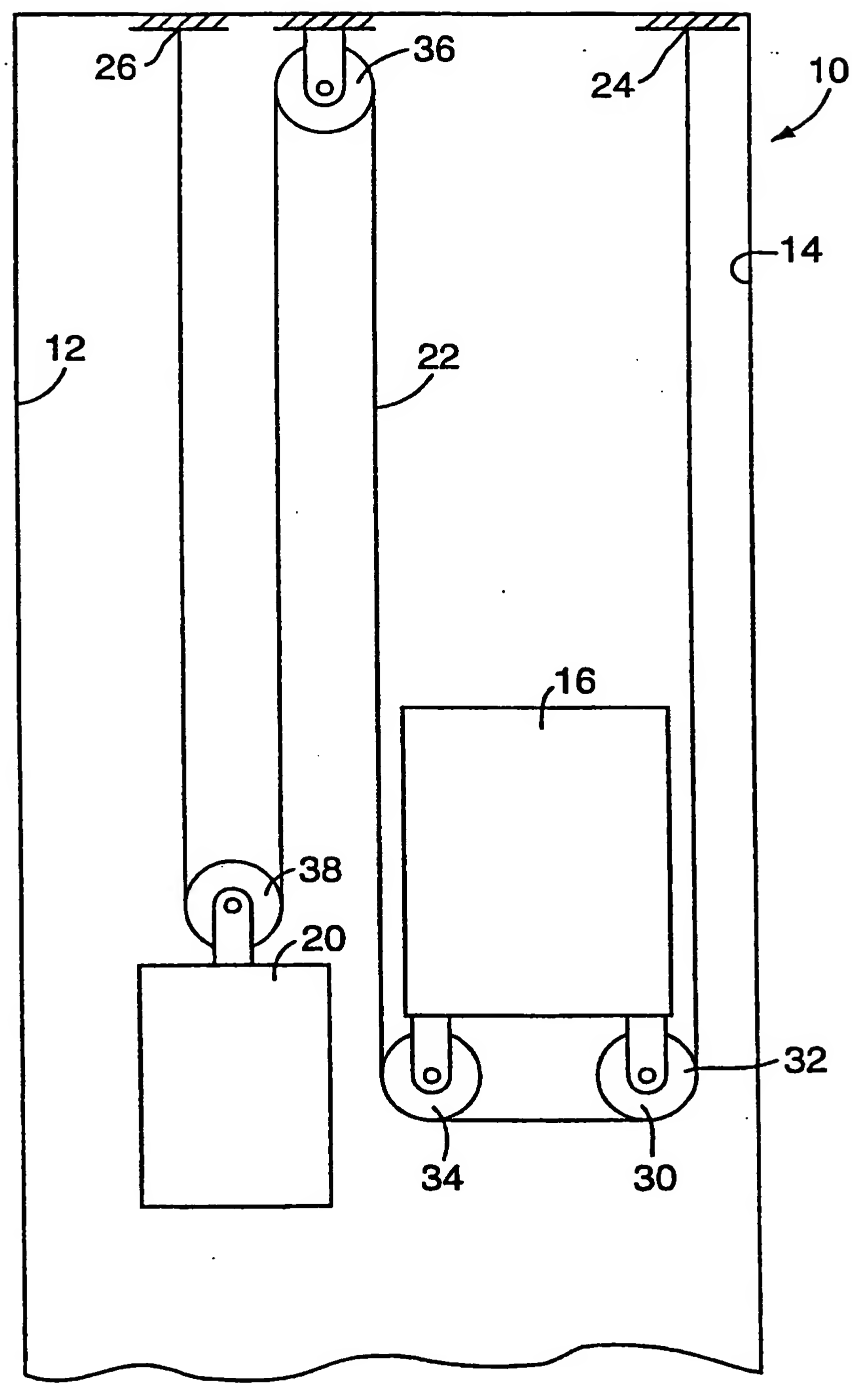

FIG. 1

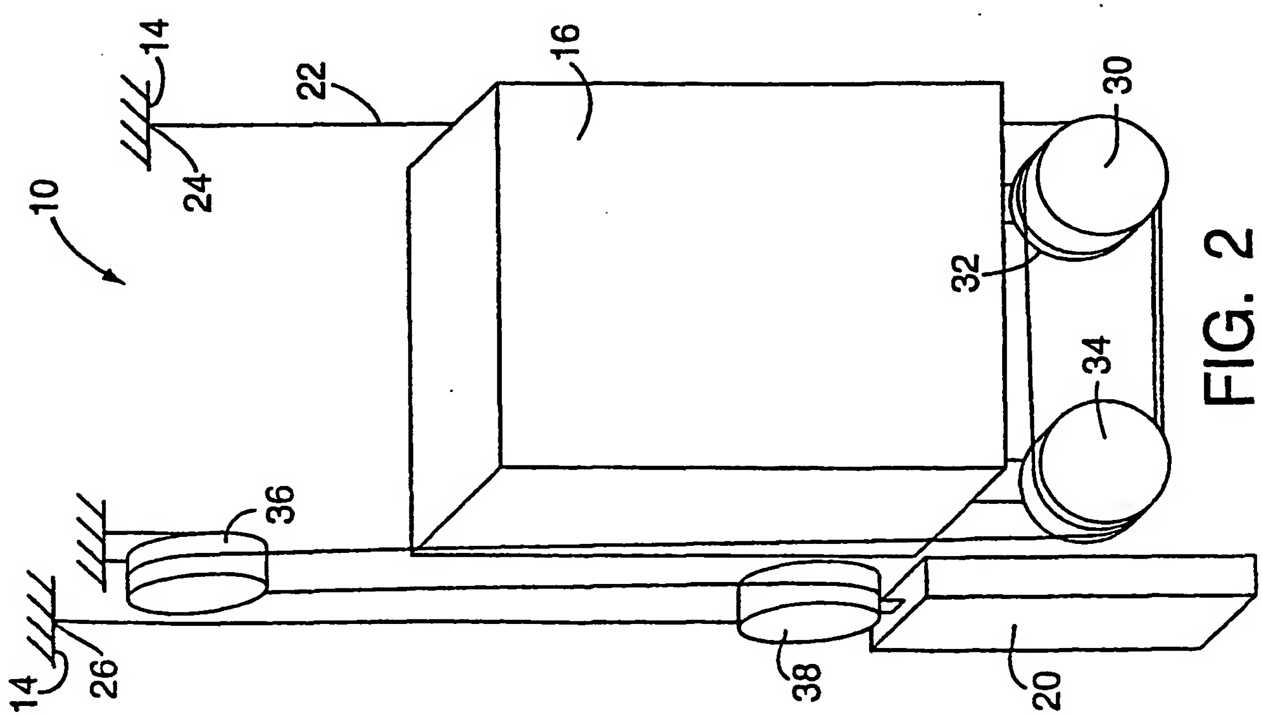
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FIG. 2

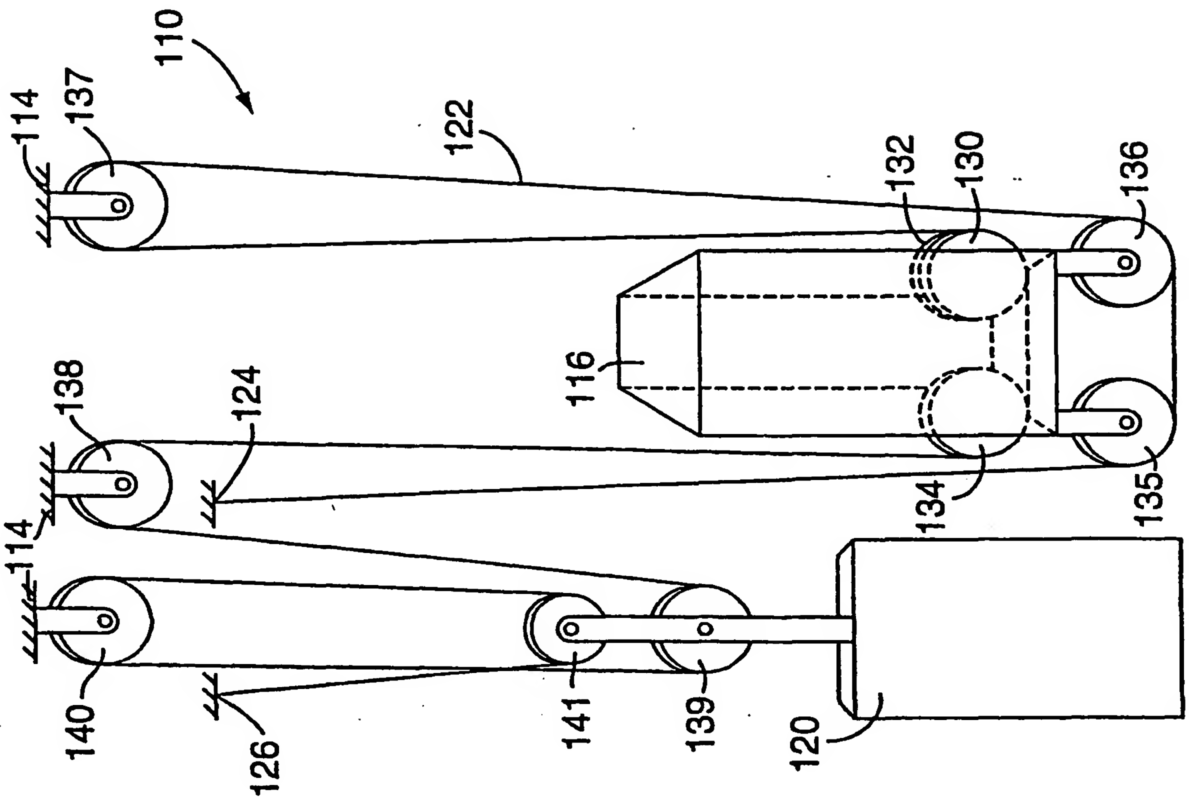
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FIG. 3

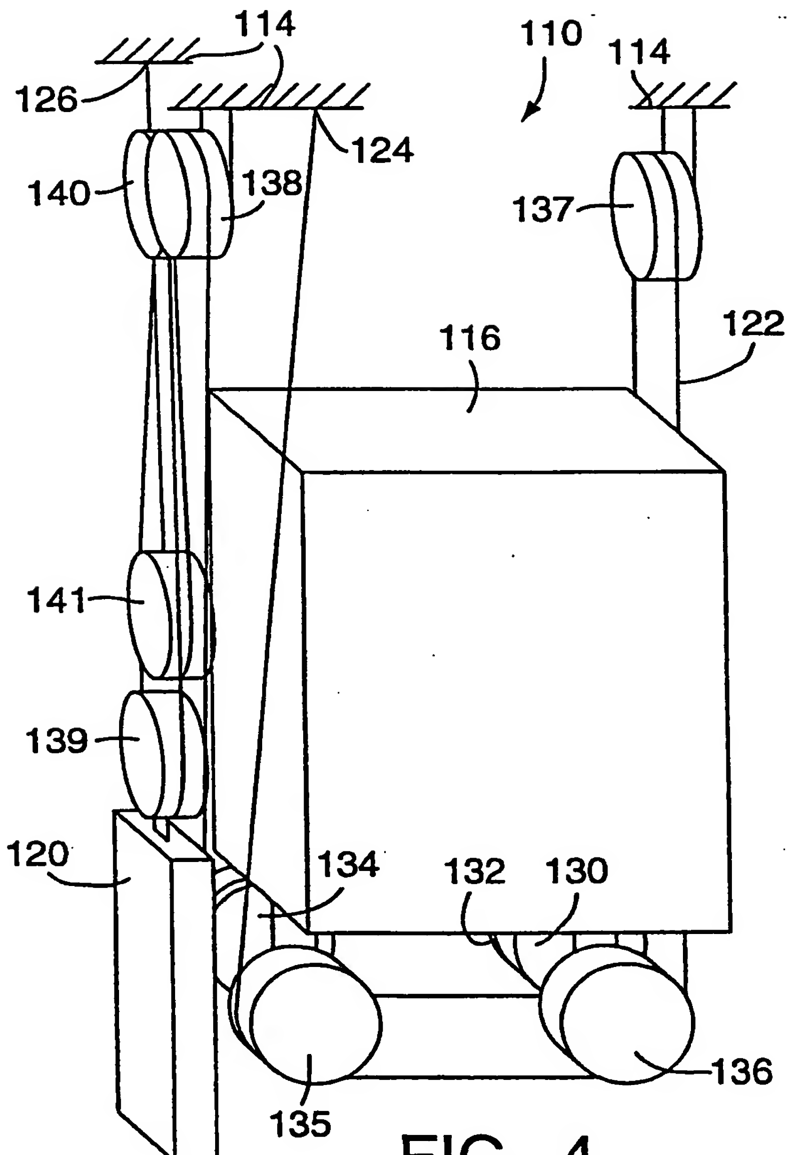
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FIG. 4

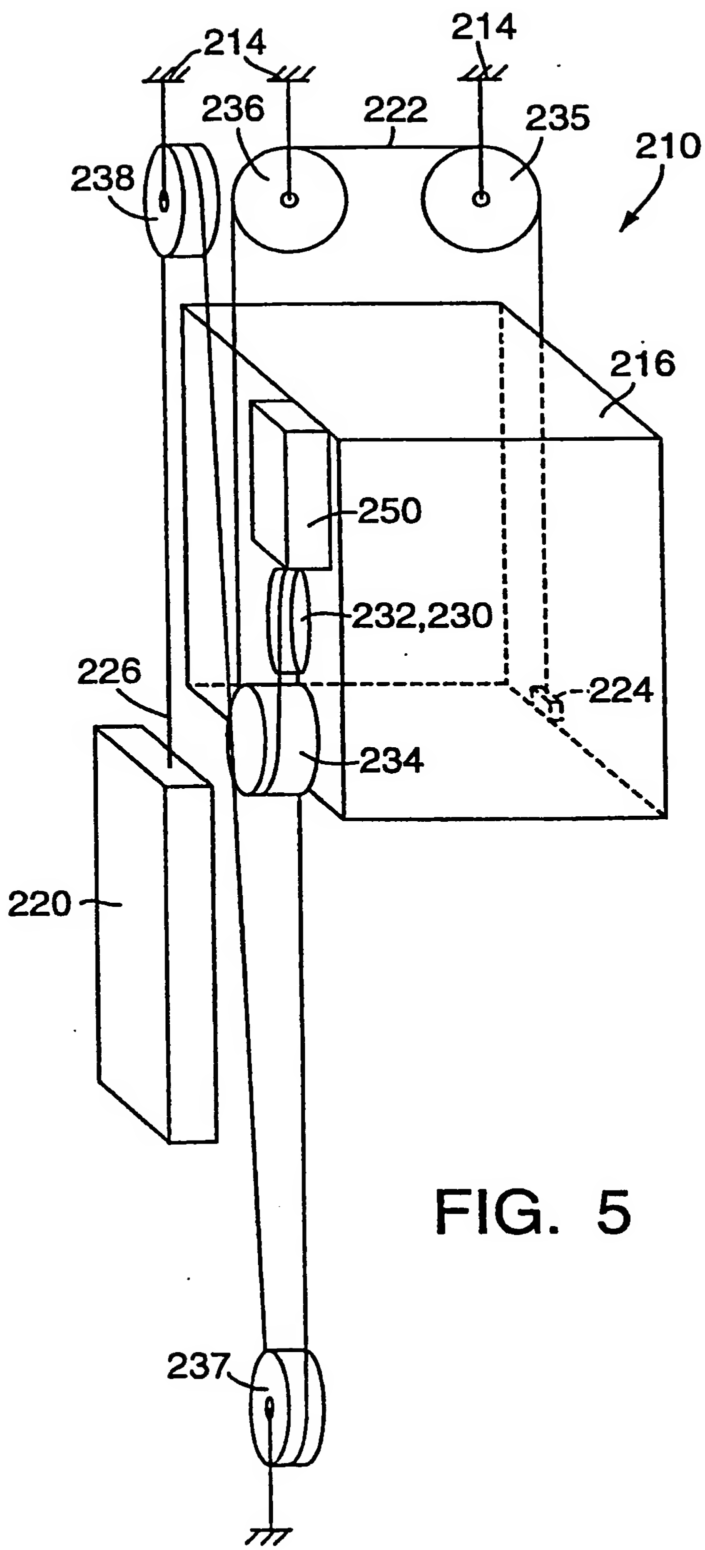
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FIG. 5

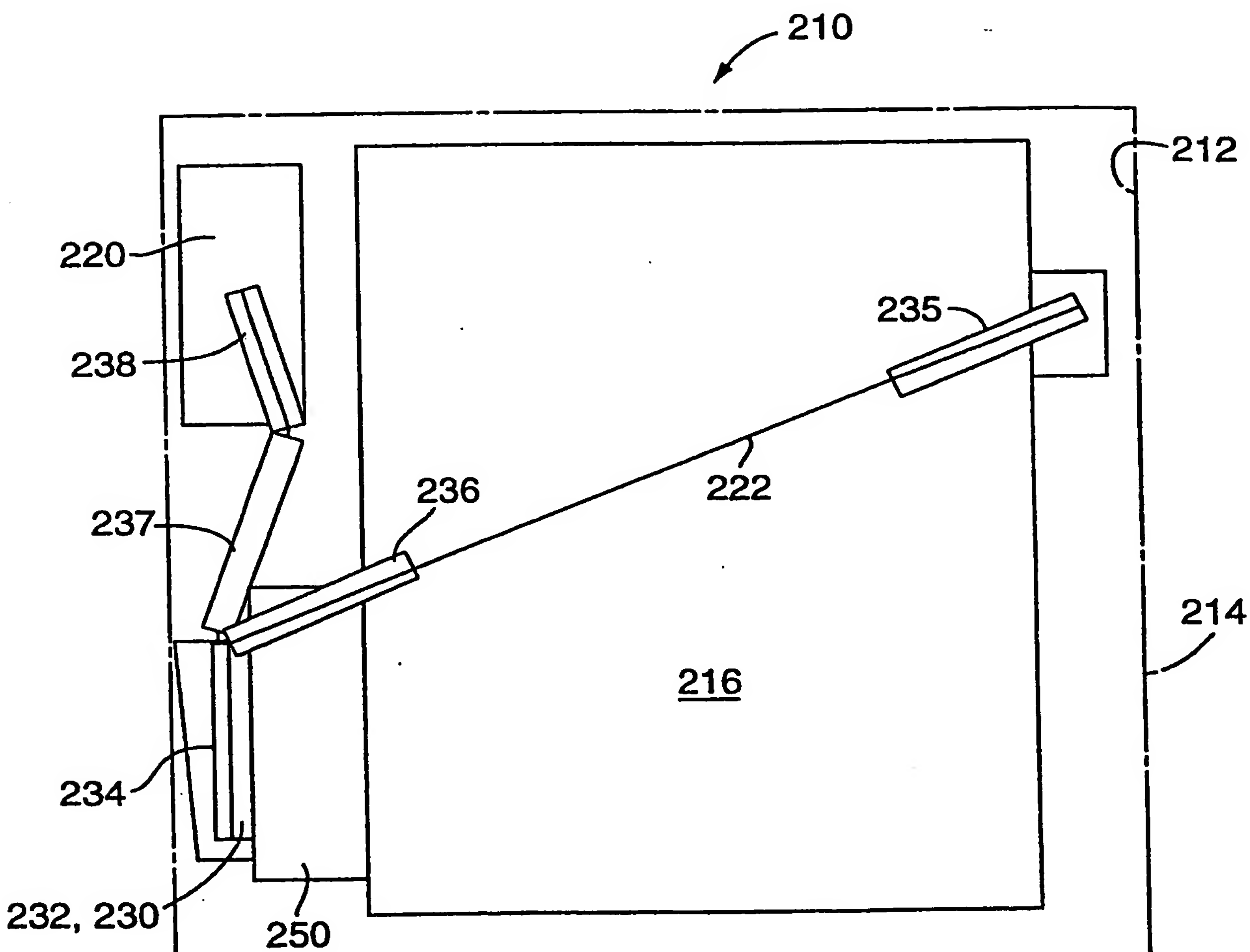

FIG. 6

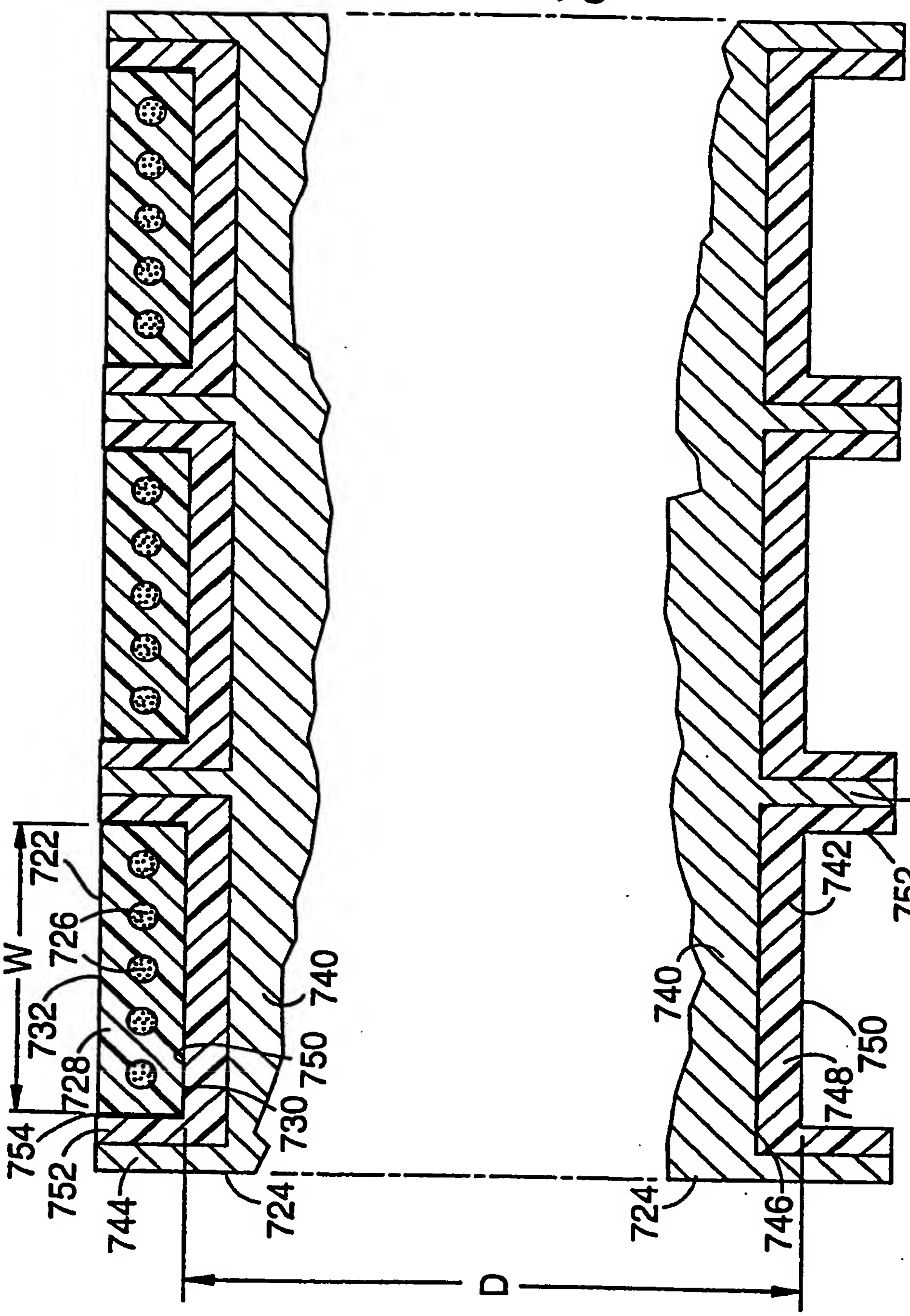
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FIG. 7

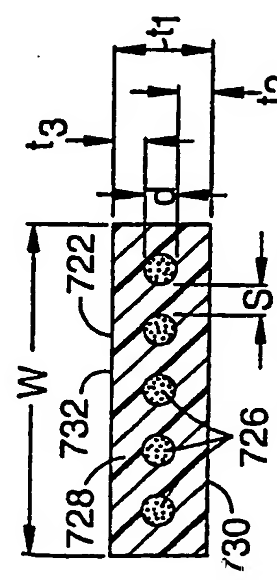
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FIG. 8